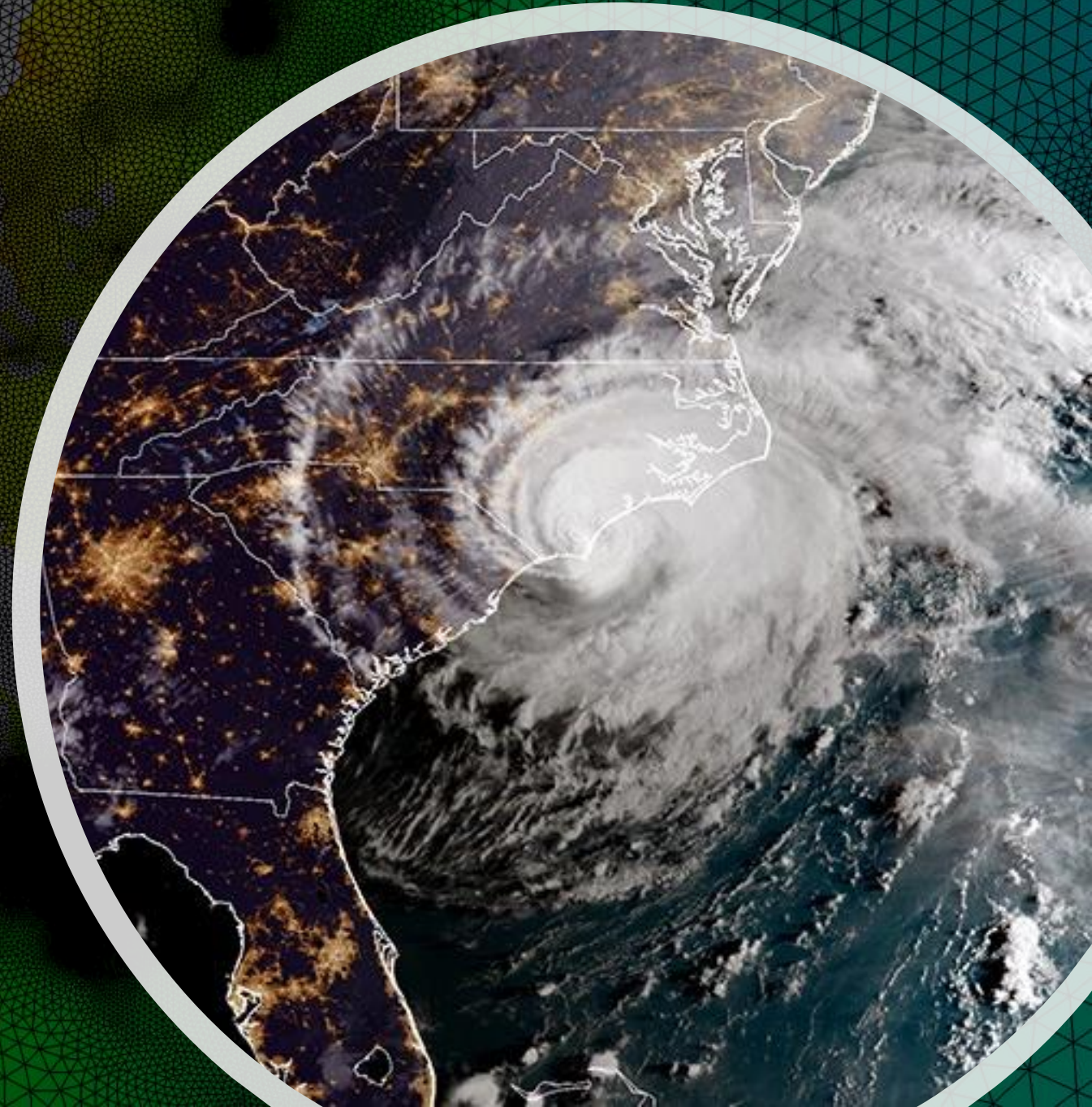


# Modeling the Storm Surge and Compound Flooding from Hurricane Florence Using ADCIRC

John Ratcliff  
M.S. Student

UNC Institute of Marine Sciences  
[John.Ratcliff@unc.edu](mailto:John.Ratcliff@unc.edu)

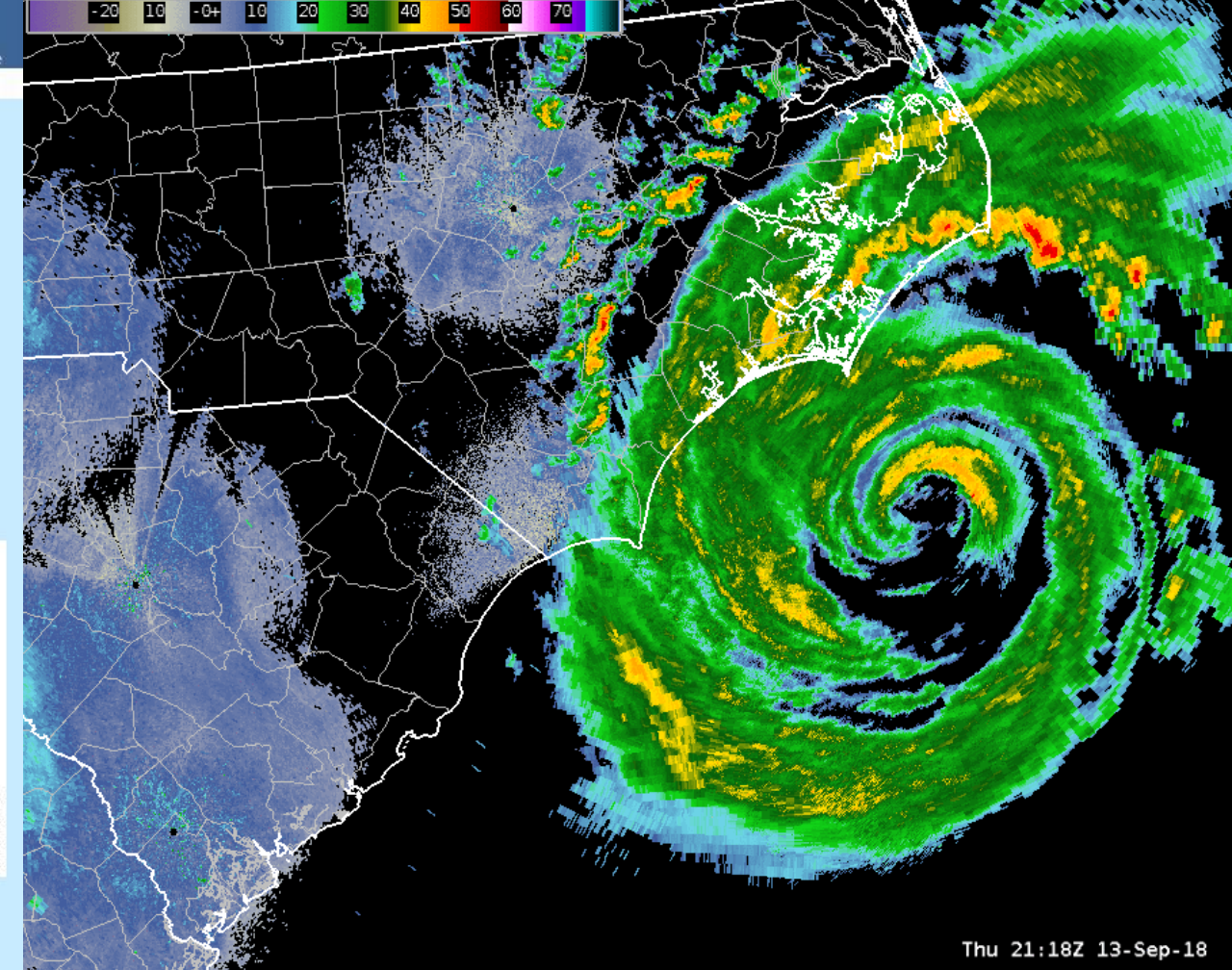
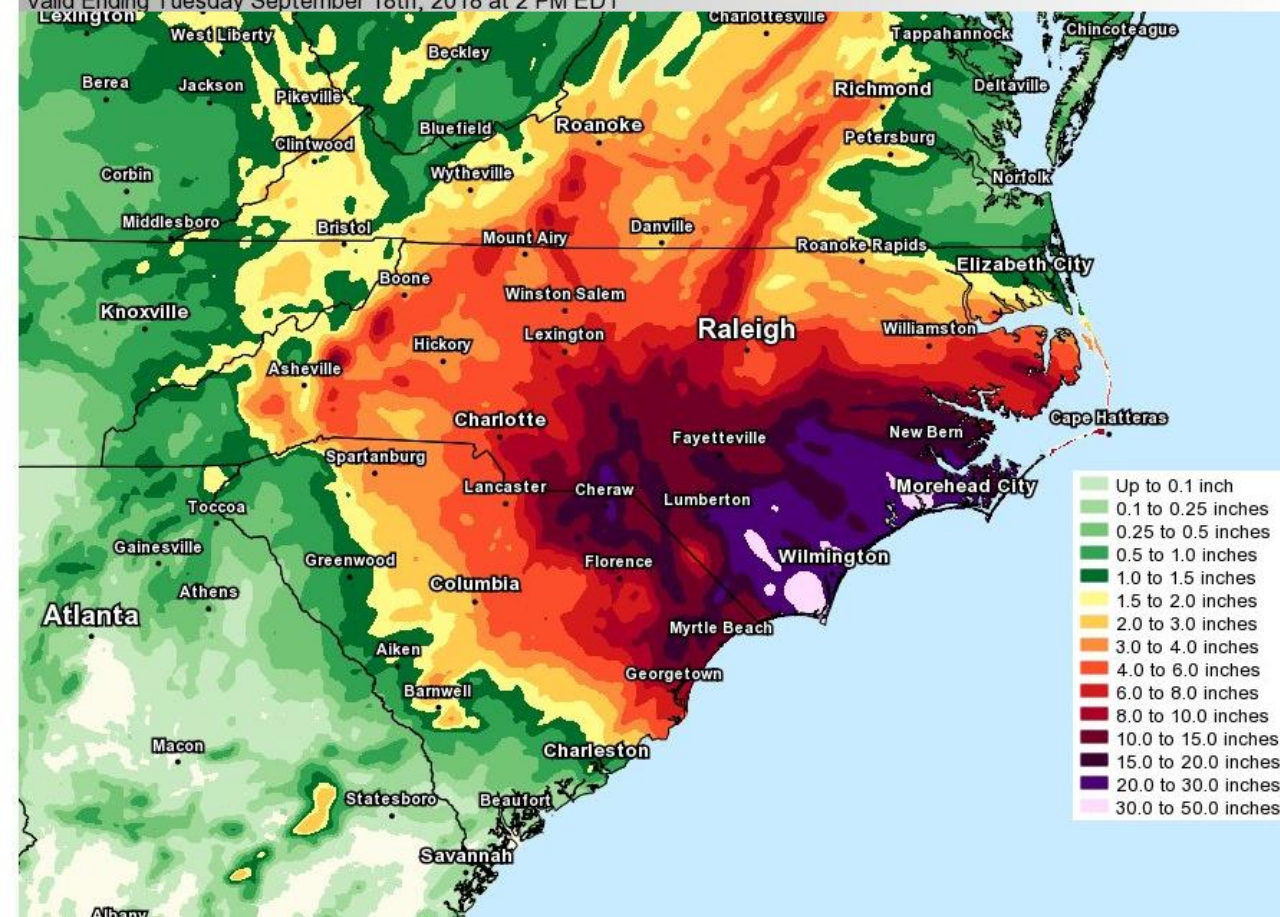
ADCIRC User's Group Meeting  
March 30-31, 2020





# Observed Precipitation

Valid Ending Tuesday September 18th, 2018 at 2 PM EDT

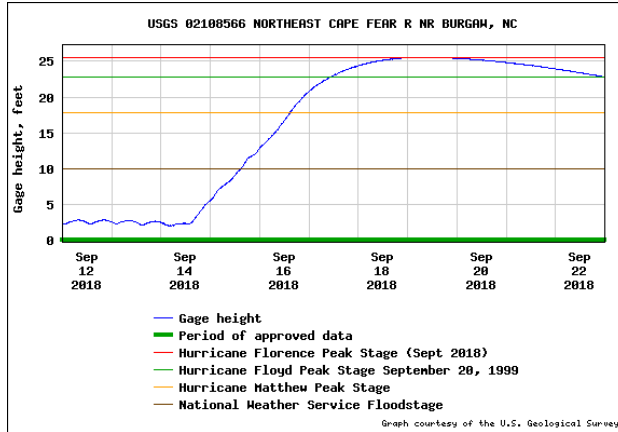


## Historic Rainfall with Slow Forward Speed & Extended Duration

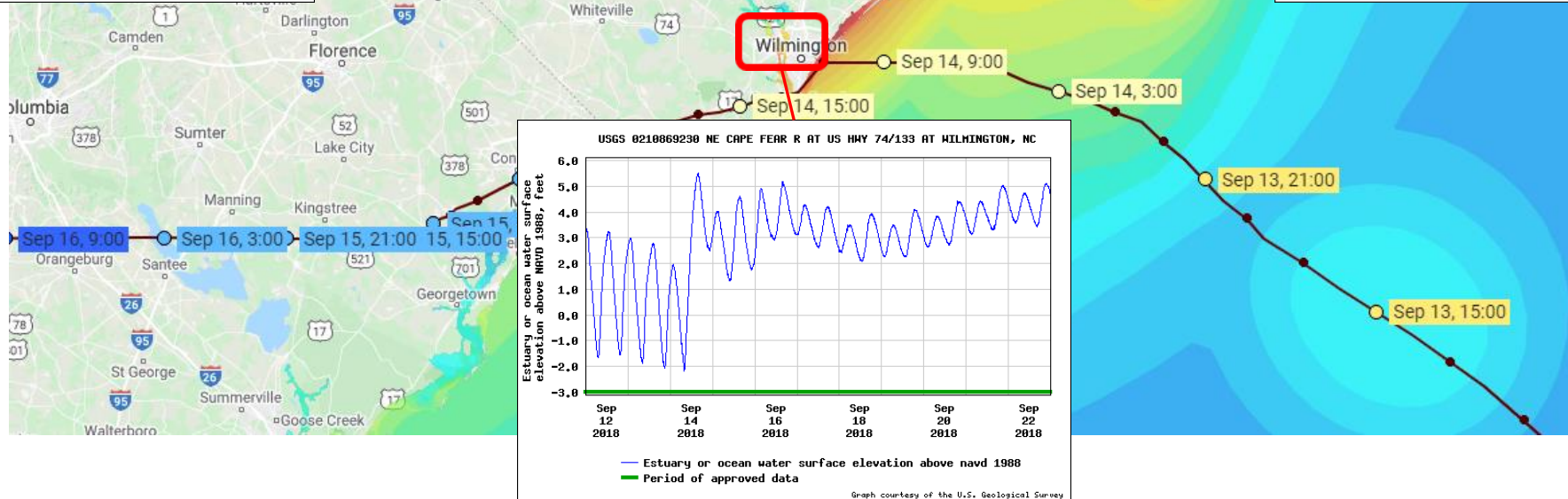
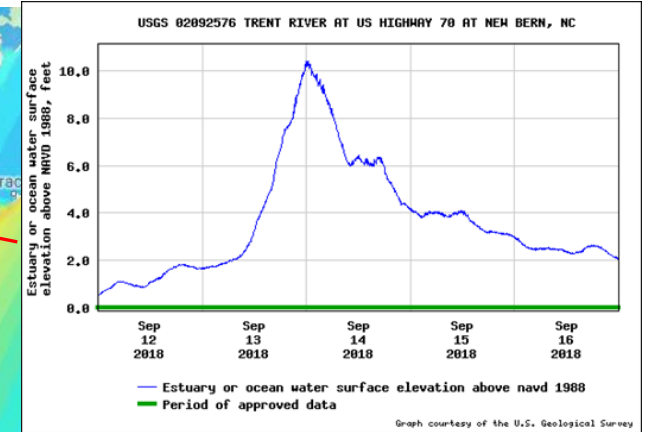


# Major Impacts

## Record Stage



## Record Storm Surge



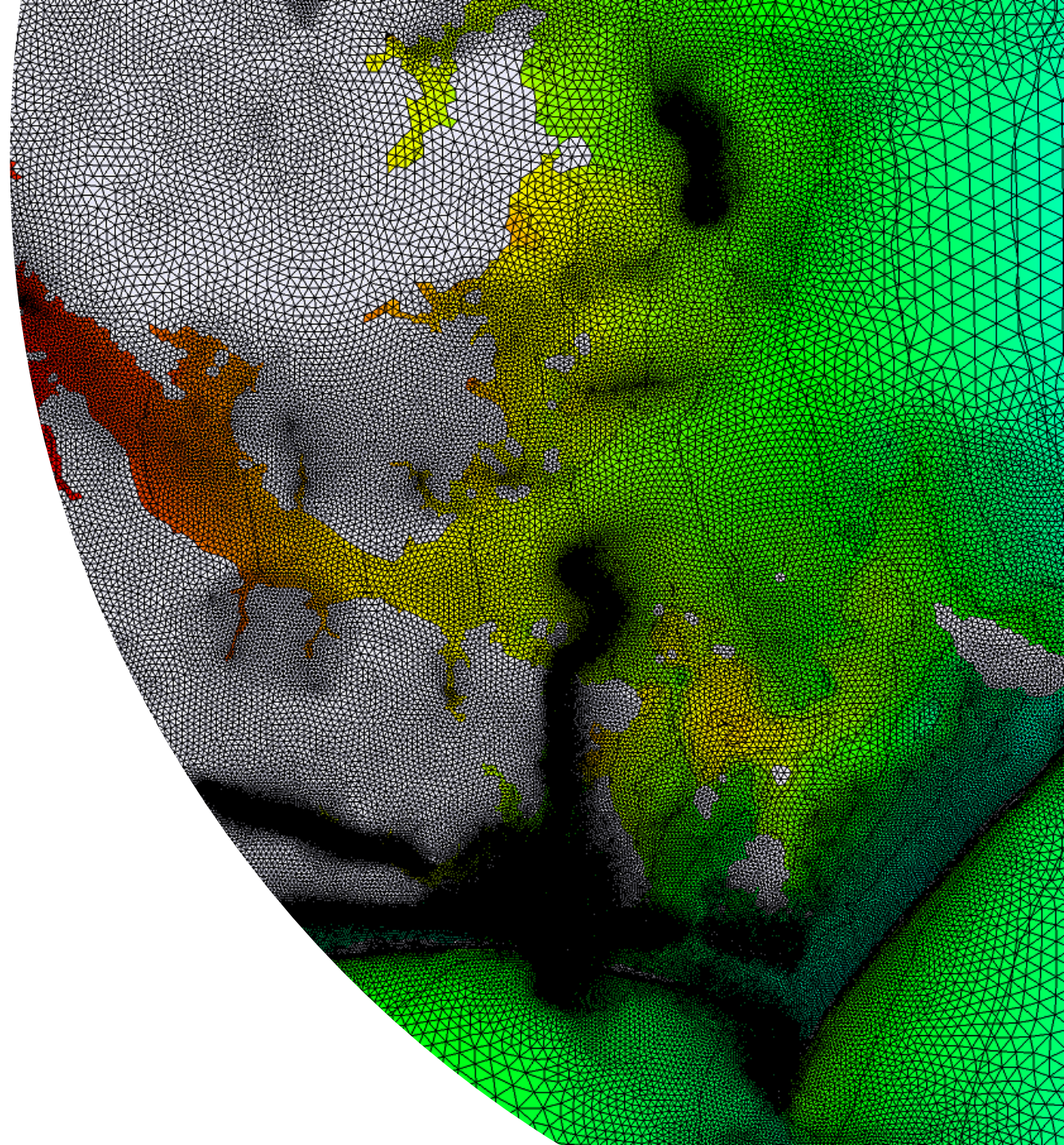
## Compound Flooding



# New Opportunities for Study with ADCIRC

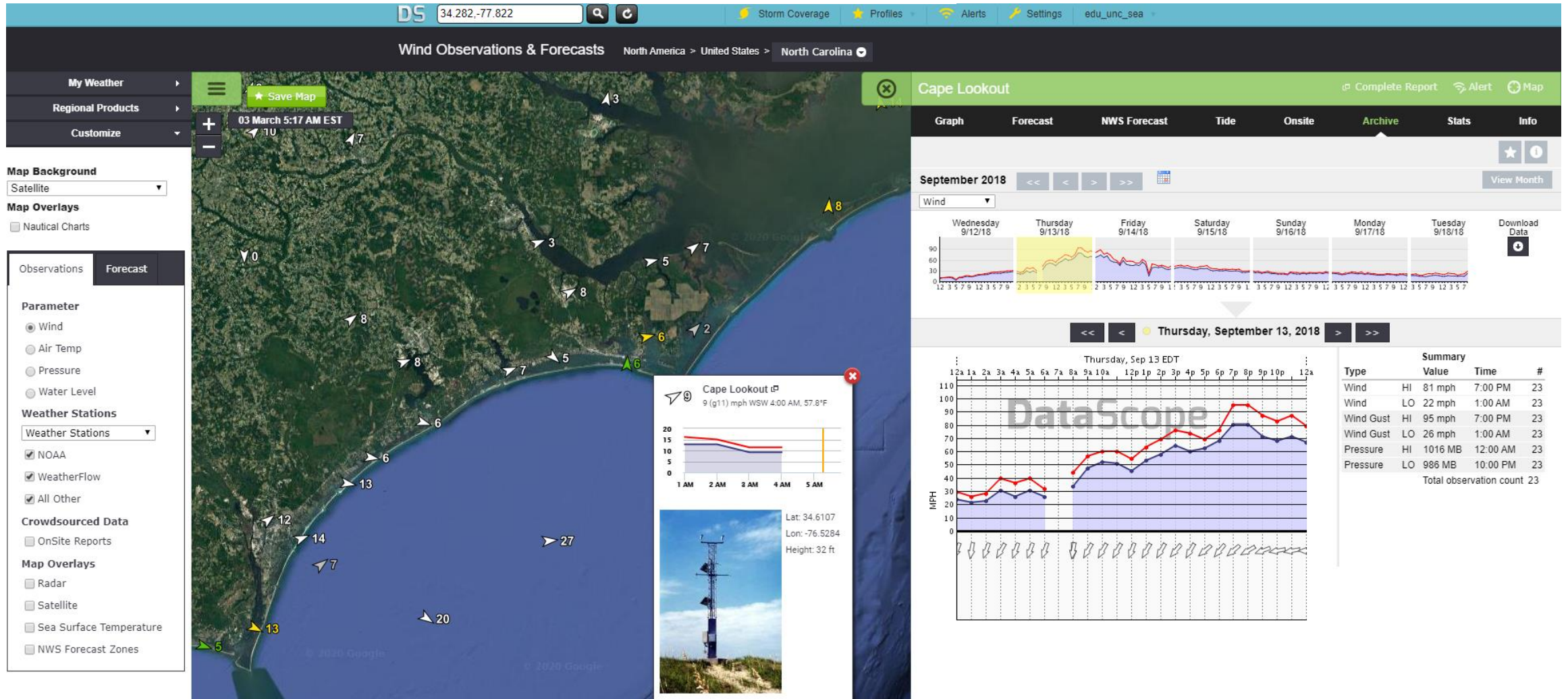
---

- Landfalling East Coast storm with perpendicular approach for ADCIRC skill assessment
- Opportunity to identify/model compound flooding
- Contribute to ‘national’ parameter set for ADCIRC users
- Normalize forecast meteorological product (GAHM) with reanalysis products (OWI)
- Examine datum adjustment (MSL → NAVD88)





# Wind Observational Data Acquisition



# Observational Wind Adjustment to 10 meters

## Wind Observation Locations with Height of Station (feet)

Hatteras Landing	35	Roanoke Sound Channel L36	17
Duck Pier	28	Croatan Sound	26
New River	32	Hatteras Airport	32
Mercer Pier	26	REAL Slick	20
Wilmington	32	Cherry Point	
North Myrtle Beach	32	Buxton	34
Beaufort	29	Avon Ocean	39
Durants Neck		Frisco Woods	20
Ocracoke	25	Waves	35
Hofmann State Forest	20	Avon Sound	15
Croatan	20	Frying Pan	
Back Island	20	KHK Resort	53
Sandy Run RAWS	20	Oregon Inlet	34
Lake Mattamuskeet		Oak Island	34
Dare Bomb Range		Fort Macon	34
Cedar Island	20	Davis	
Federal Point	49.5	Sunset Beach Buoy	9
Pamlico Sound	43	Wilmington Buoy	10
Swan Beach		Kill Devil Hills	
New Bern	32	Chadwick Shores	
Sandy Point		N4QLD Hertford	
Pea Ridge		EC Airport	32
Gun Point		Edenton	33
North River	18	Alligator Bridge	38
EW5987 Trent Woods NC US		Manteo	33
TRENT RIVER AT HWY 1 IN TRENTON NC US		Oregon Inlet CG	34
Southern Shores		Cape Lookout	32
Corolla Light		Topsail Beach South	
FW1502 Corolla NC US	20	Creswell	29
		Hatteras High	65
		Sunset	
		Jennettes Pier	60

**Wind adjustment to 10 m using ‘log law’:**

$$U_{10} = U_z \frac{\ln\left[\frac{10 - Z_D}{Z_0}\right]}{\ln\left[\frac{Z - Z_D}{Z_0}\right]}$$

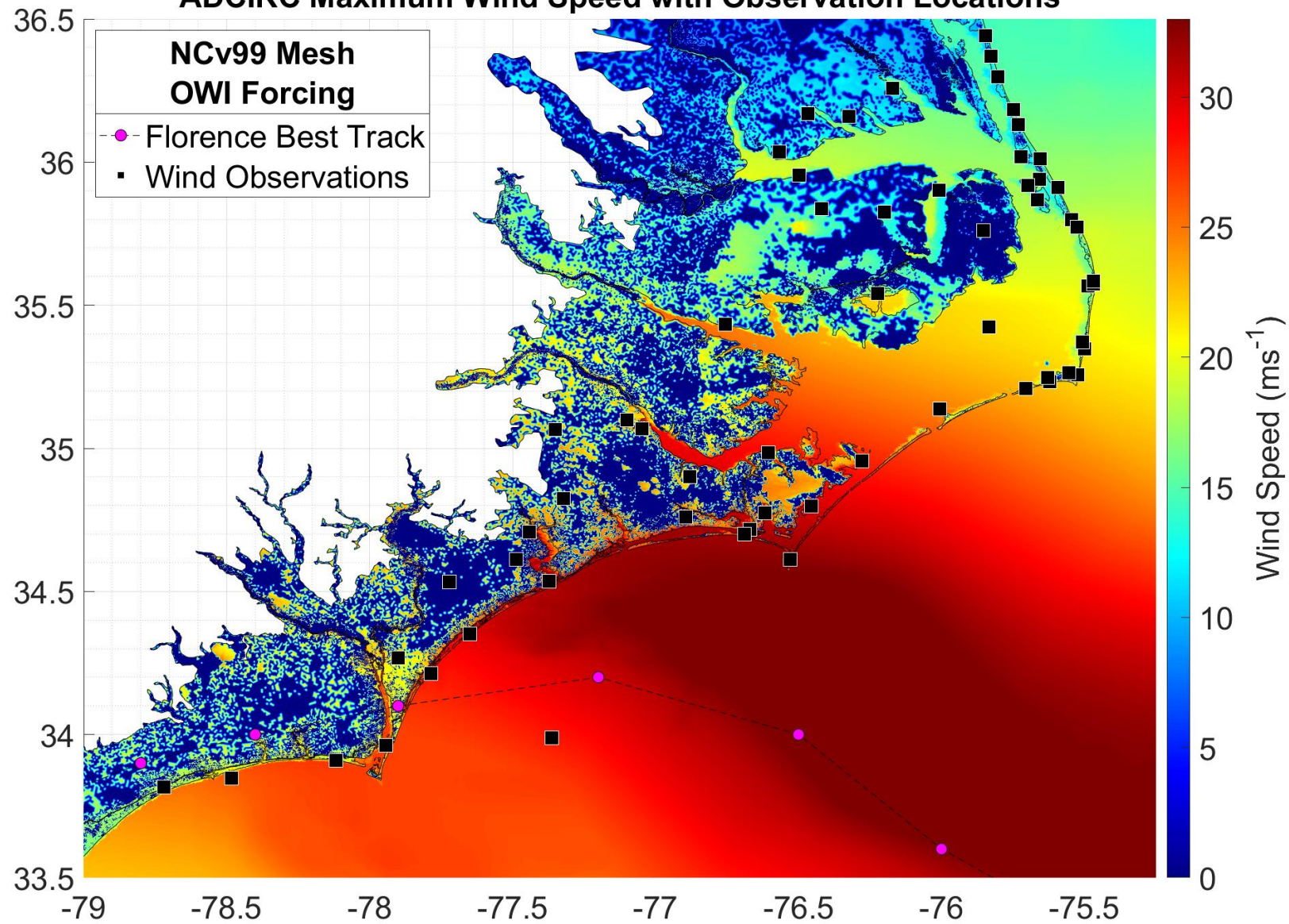
$U_{10}$  = 10 m level wind speed

$U_z$  = mean surface wind measurements

$Z_D$  = zero – plane displacement height

$Z_0$  = surface roughness length

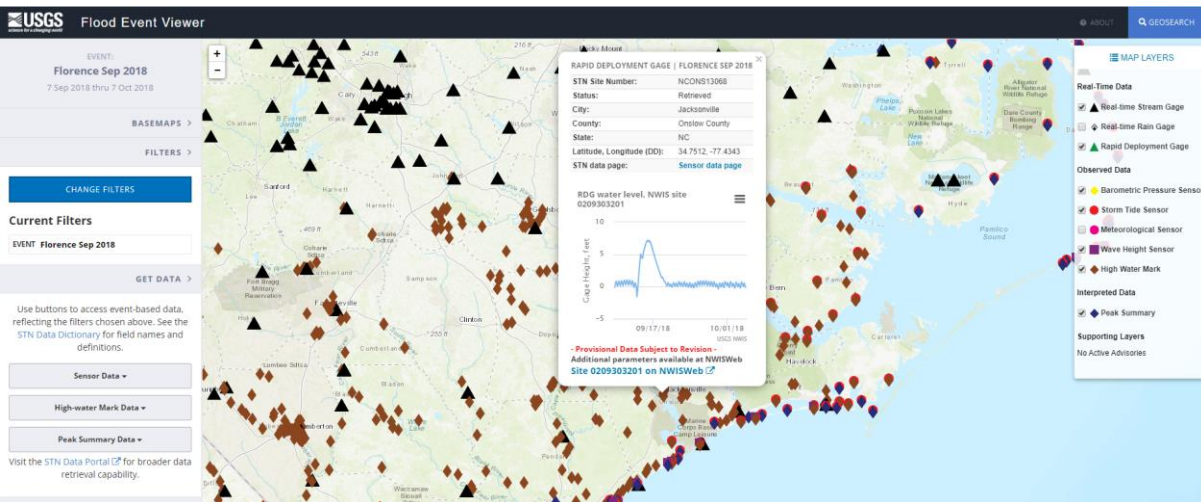
# ADCIRC Maximum Wind Speed with Observation Locations





# Water Level Observational Data Acquisition

## USGS Flood Event Viewer



## Today's Tides

Time	Tide	Height
7:04 PM	Low	0.19 ft
1:28 AM	High	2.85 ft
8:19 AM	Low	0.47 ft
1:50 PM	High	2.22 ft

**Recent Data** as of 3/3/2020 5:24 AM  
Local Time



**Water Level:** 1.39 ft Above MLLW  
**Next Tide at 8:19 AM:** Low 0.47 ft



**Water Temp:** 53.6 ° F  
**Air Temp:** 54.3 ° F  
**Barometric Pressure:** 1013.4 mb  
**Winds:** 3.1 kts from SSW  
**Gusting to:** 3.8 kts from SSW

☐ Plot Data

**Standard**

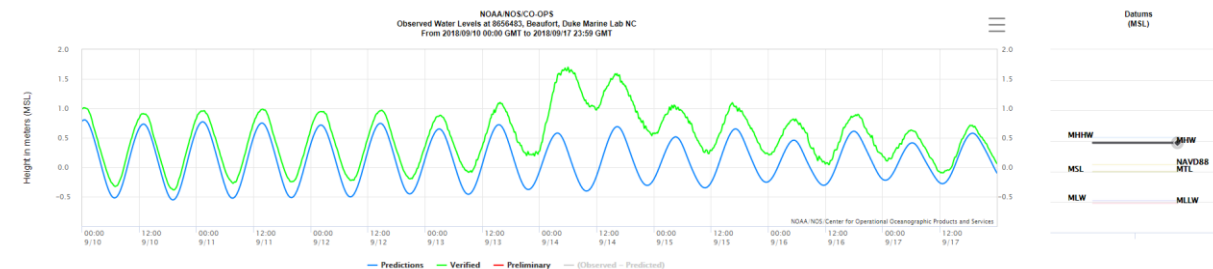
Metric

Auto-Refresh:




Home / Products / Water Levels / 8656483 Beaufort, Duke Marine Lab, NC ☆ Favorite Stations

Station Info Tides/Water Levels Meteorological Obs Phys Oceanography





# Adjusted Water Level Datums Using NOAA VDatum

 **NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION**  
UNITED STATES DEPARTMENT OF COMMERCE

## ONLINE VERTICAL DATUM TRANSFORMATION

INTEGRATING AMERICA'S ELEVATION DATA

[Home](#) | [About VDatum](#) | [Download](#) | [Docs & Support](#) | [Contact Us](#)

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**Regional Information**

\* Region : Contiguous United States

---

**Horizontal Information**

	Source	Target
Reference Frame:	<span>NAD83(2011)</span>	<span>NAD83(2011)</span>
Coor. System:	<span>Geographic (Longitude, Latitude)</span>	<span>Geographic (Longitude, Latitude)</span>
Unit:	<span>meter (m)</span>	<span>meter (m)</span>
Zone:	<span>AL E - 0101</span>	<span>AL E - 0101</span>

---

☒ **Vertical Information**

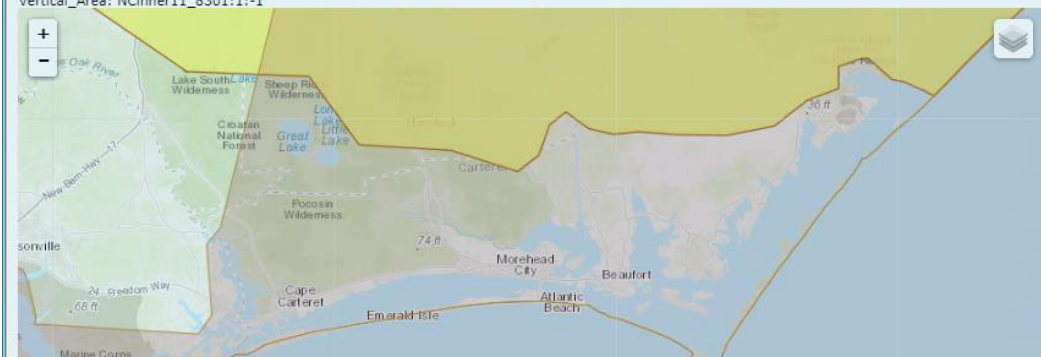
	Source	Target
Reference Frame:	<span>NAVD 88</span>	<span>LMSL</span>
Unit:	<span>meter (m)</span>	<span>meter (m)</span>
	<input checked="" type="radio"/> Height <input type="radio"/> Sounding	<input checked="" type="radio"/> Height <input type="radio"/> Sounding
	<input type="checkbox"/> GEOID model: <span>GEOID12B</span>	<input type="checkbox"/> GEOID model: <span>GEOID12B</span>

---

[Point Conversion](#) | [ASCII File Conversion](#)

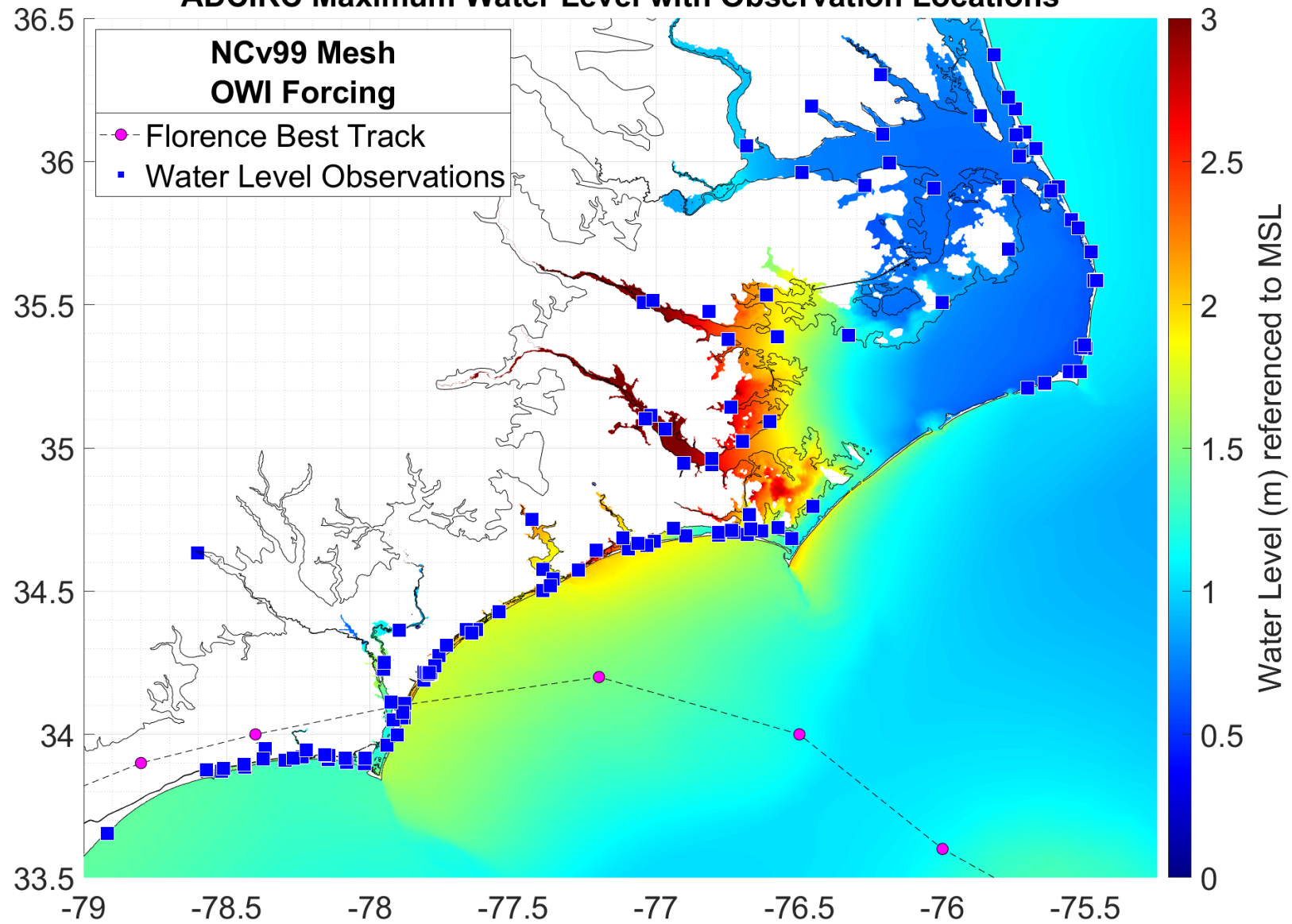
Input		Output	
Longitude:	<span>-76.67062</span>	Longitude:	<span>-76.6706200000</span>
Latitude:	<span>34.71731</span>	Latitude:	<span>34.7173100000</span>
Height:	<span>0</span>	Height:	<span>0.107</span>
<input type="button" value="Drive to on map"/> <input type="button" value="Reset Map"/>		<input type="button" value="Drive to on map"/> <input type="button" value="Reset Map"/>	
<input type="checkbox"/> to DMS		Vertical Uncertainty (+/-): <span>6.95773 cm</span>	

Vertical\_Area: NCinner11\_8301:1:-1





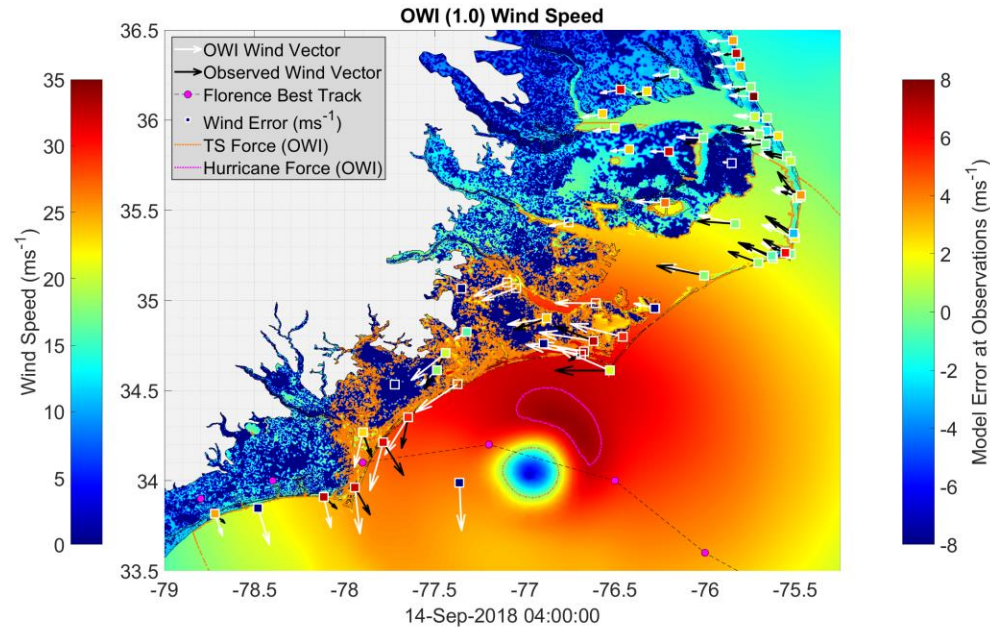
### ADCIRC Maximum Water Level with Observation Locations





# 2 Meteorological Forcing Products Used in Study

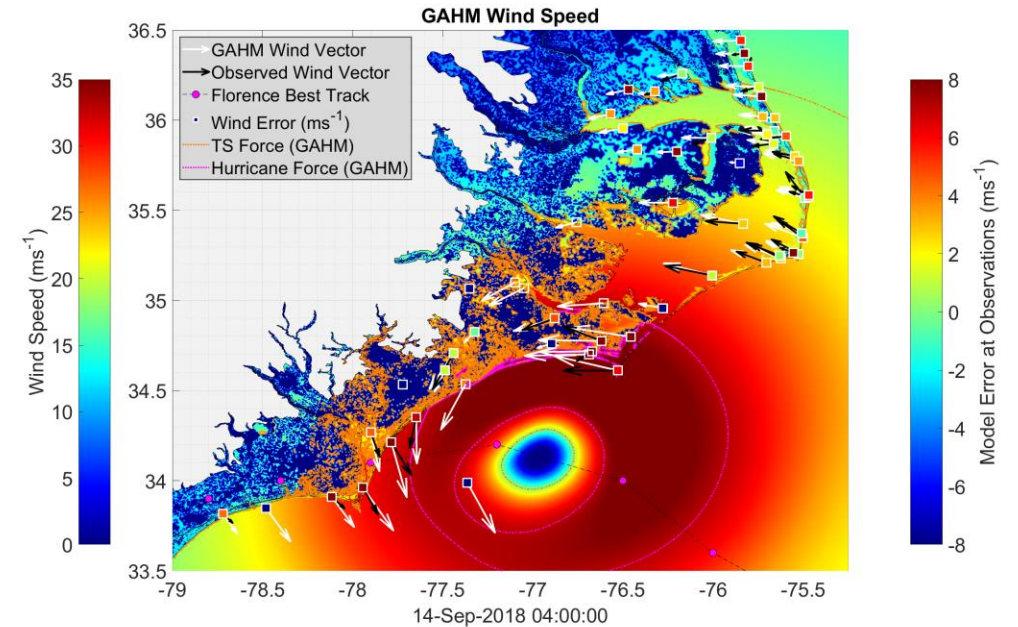
Ocean Weather, Inc. (OWI)



Re-analysis Product

Used for hindcast analysis

Generalized Asymmetric Holland Model  
(GAHM), Gao et al. (2017)



Parametric Wind Model that Uses Best Track  
Data from National Hurricane Center

Used in real-time ADCIRC forecasting



# Several Parameter Combinations Compared

## ADCIRC

### Fort.15 - Model Parameters and Periodic Boundary Conditions

- **FFactor**- Bottom Friction Coefficient
  - Settings used: **0, 0.001, 0.003**
- **WindDragLimit**- Ceiling on Wind Drag Coefficient
  - **0.002, 0.0025, 0.0028**

### Fort.22 — Meteorological Forcing Data

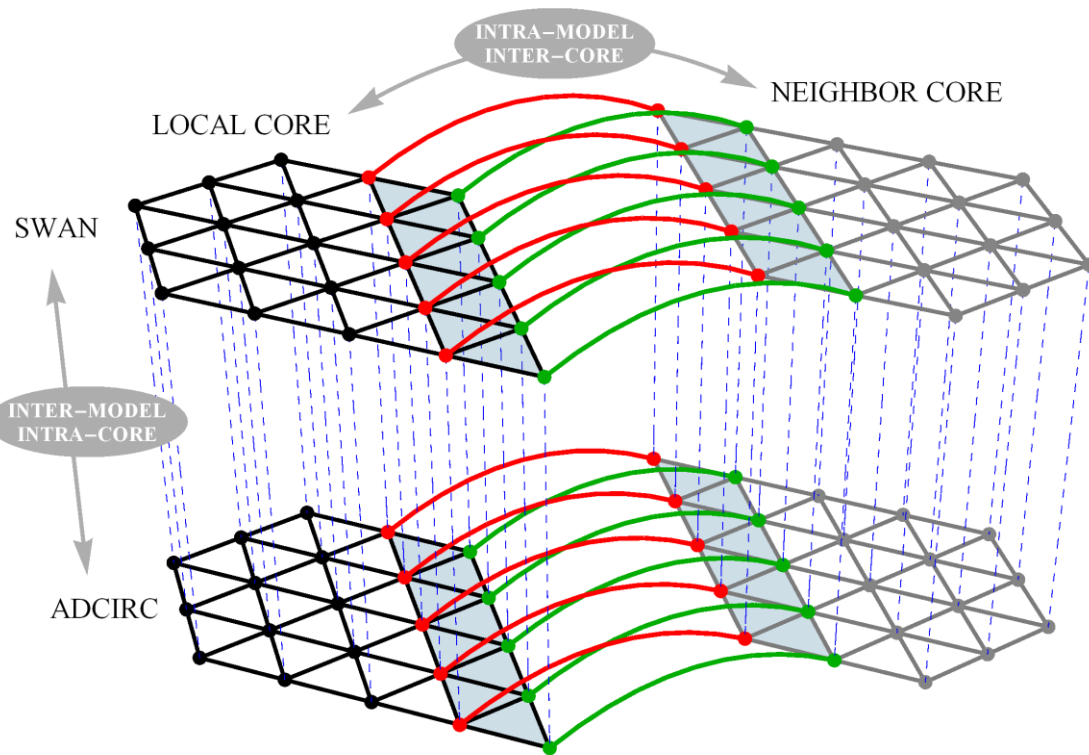
- **DWM (NWM=-312)**- Multiplication Factor for Wind Velocities
  - **1.0, 1.09** (OWI Wind Scaling)

Community	Documentation	Related software	News	Products	ASGS
<a href="#">Home</a> » » <a href="#">Documentation</a> » <a href="#">User's Manual - v53</a> » <a href="#">Input File Descriptions</a>					
<h3>Input File Descriptions</h3>					
<a href="#">Grid and Boundary Information File (fort.14)</a> - required					
<a href="#">Model Parameter and Periodic Boundary Condition File (fort.15)</a> - required					
<a href="#">Passive Scalar Transport Input File (fort.10)</a> - conditional					
<a href="#">Density Initial Condition Input File (fort.11)</a> - conditional					
<a href="#">Nodal Attributes File (fort.13)</a> - conditional					
<a href="#">Non-periodic Elevation Boundary Condition File (fort.19)</a> - conditional					
<a href="#">Non-periodic, Normal Flux Boundary Condition File (fort.20)</a> - conditional					
<a href="#">Meteorological Forcing Data (fort.22)</a> - conditional					
<a href="#">Multiple File Meteorological Forcing Input (fort.200,?.)</a> - conditional					
<a href="#">Wave Radiation Stress Forcing File (fort.23)</a> - conditional					
<a href="#">Self Attraction/Earth Load Tide Forcing File (fort.24)</a> - conditional					
<a href="#">Ice Coverage Input Files (fort.25, 225/227)</a> - conditional					
<a href="#">Level of No Motion Boundary Condition Input (fort.35)</a> - conditional					
<a href="#">Salinity Boundary Condition Input (fort.36)</a> - conditional					
<a href="#">Temperature Boundary Condition Input (fort.37)</a> - conditional					
<a href="#">Surface Temperature Boundary Values (fort.38)</a> - conditional					
<a href="#">Salinity and Temperature River Boundary Values (fort.39)</a> - conditional					
<a href="#">2DDI Hot Start Files (fort.67 or fort.68)</a> - conditional					
<a href="#">Time Varying Bathymetry Input File (fort.141)</a> - conditional					
<a href="#">Elevation Station Location input file (elev_stat.151)</a> - conditional					

<http://adcirc.org/>

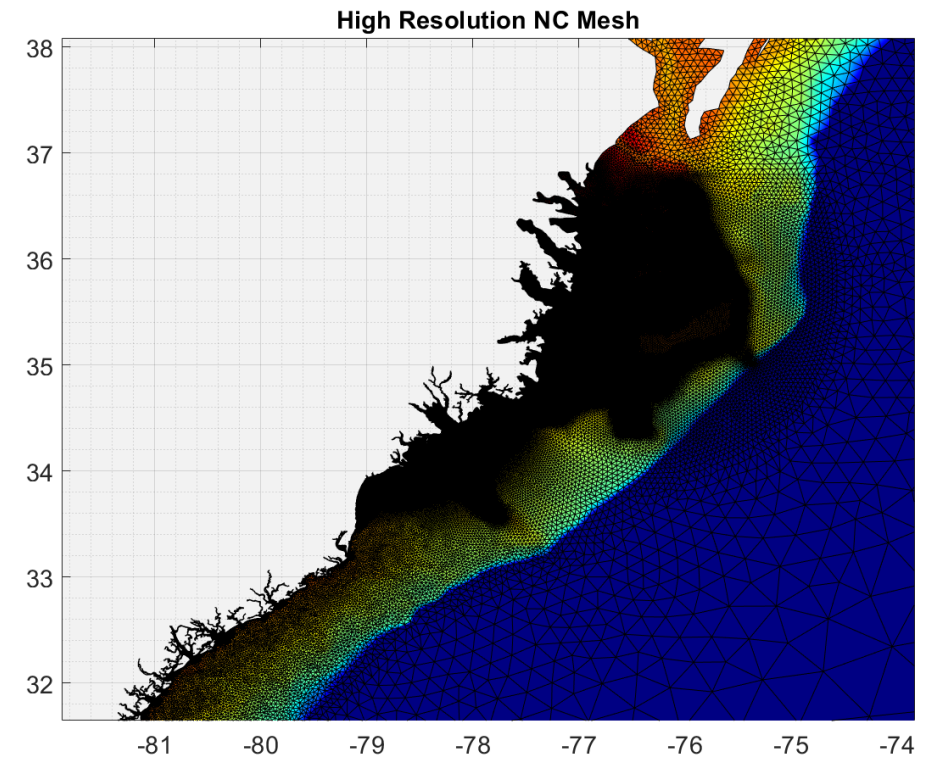


# ADCIRC + SWAN

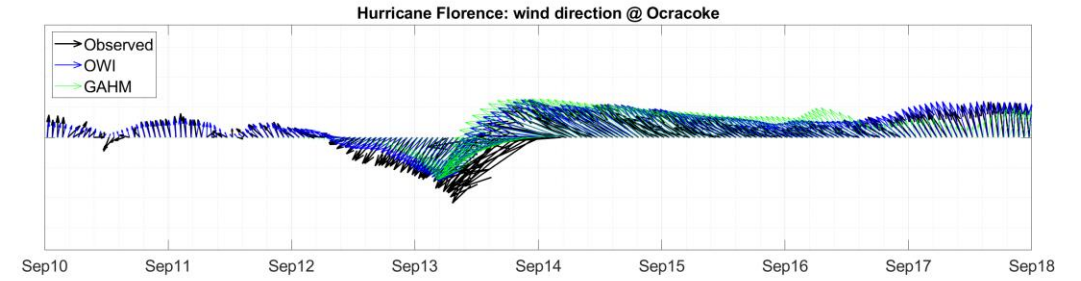
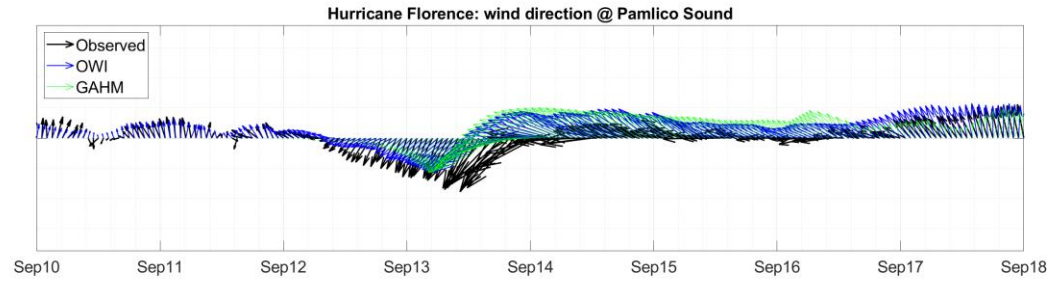
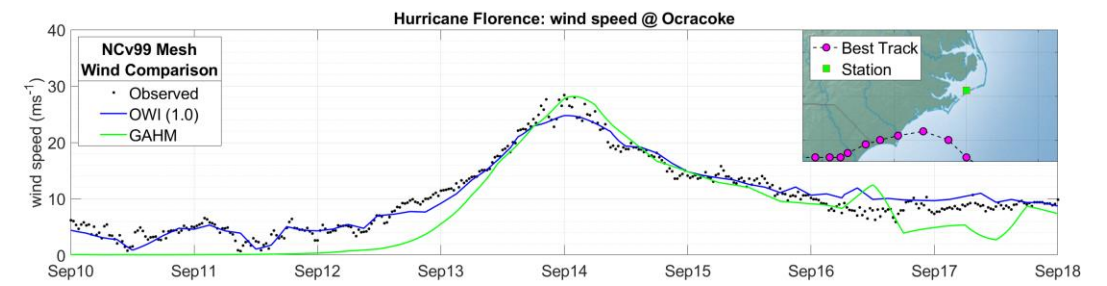
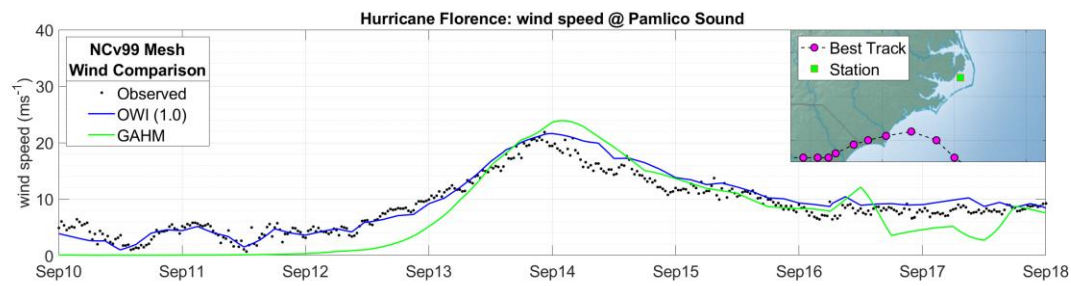


Dietrich et al., 2011

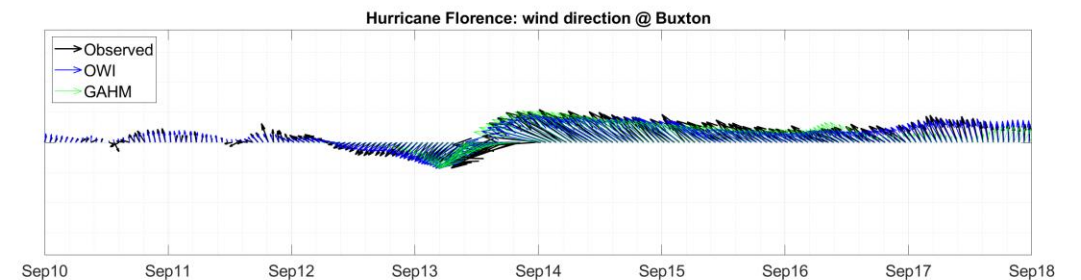
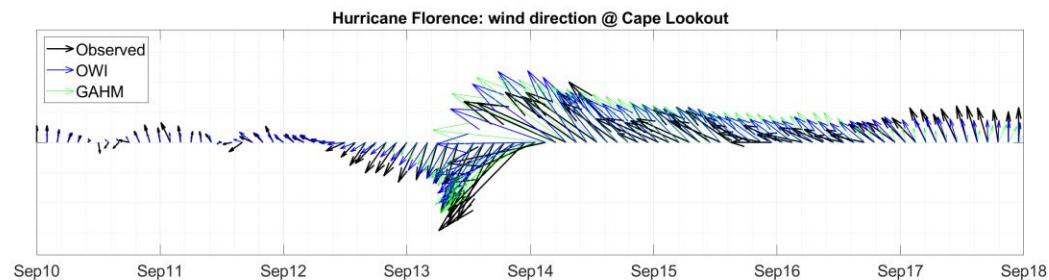
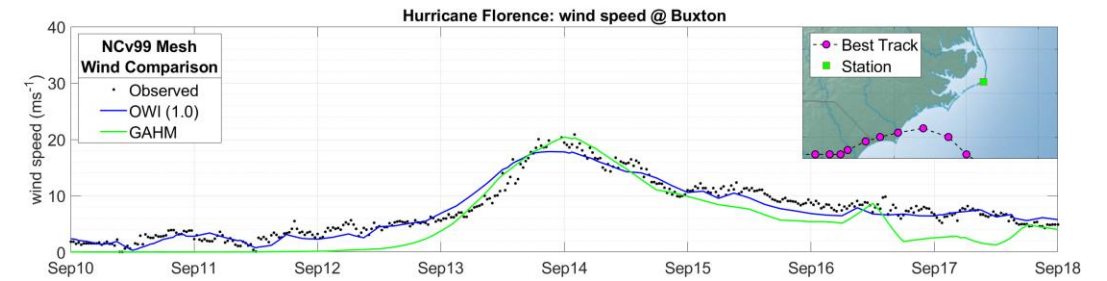
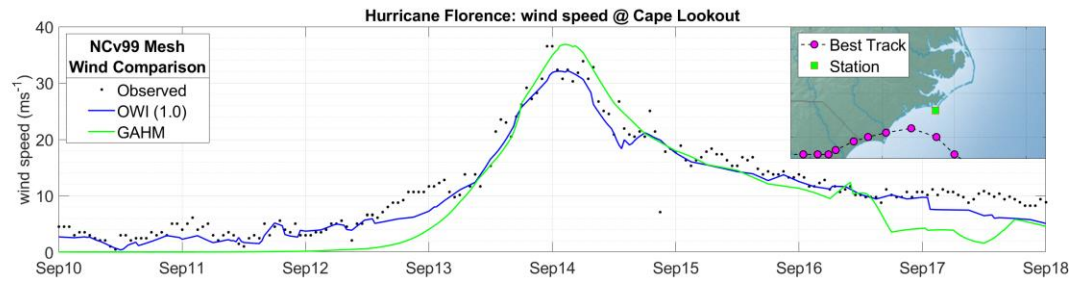
# High Res. NC Mesh



nc\_inundation\_v9.99a\_w\_rivers

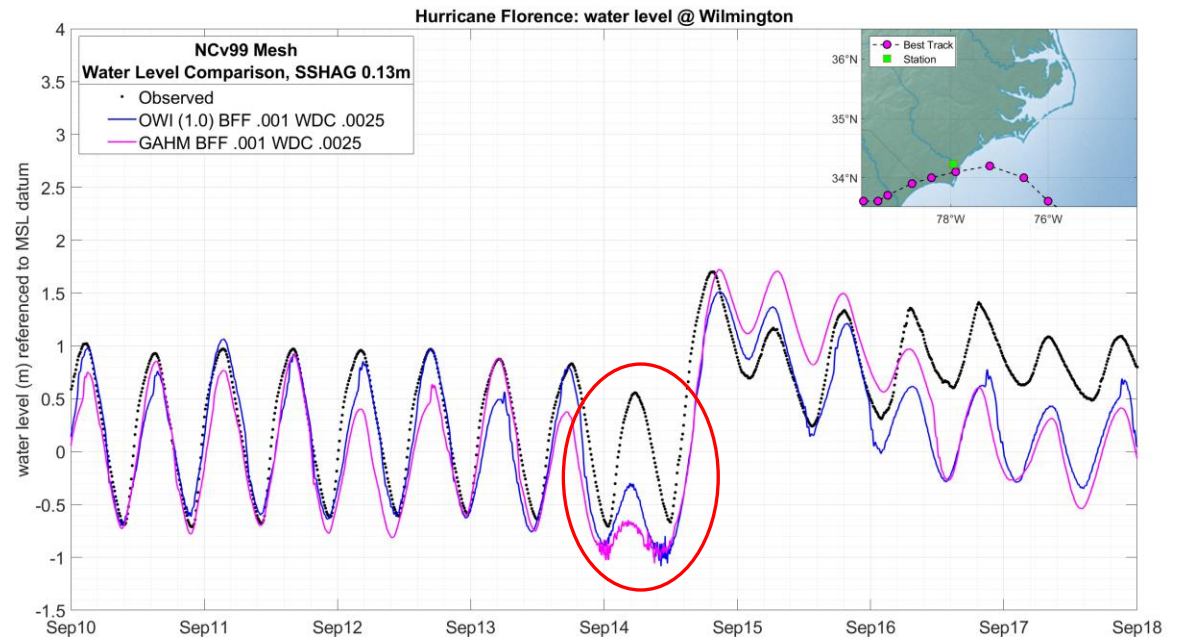
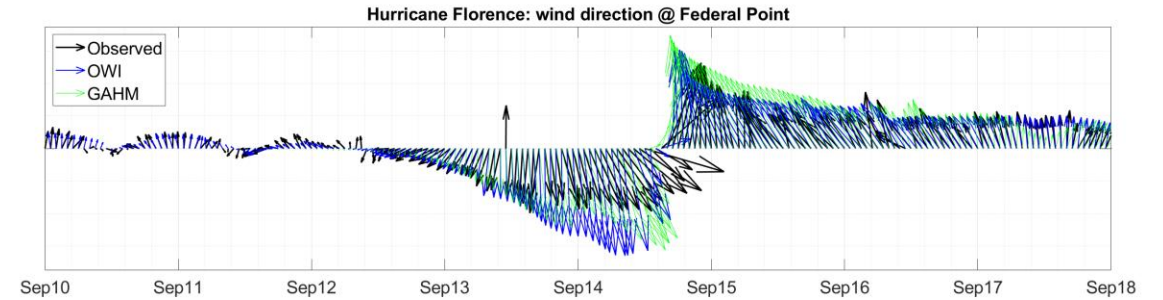
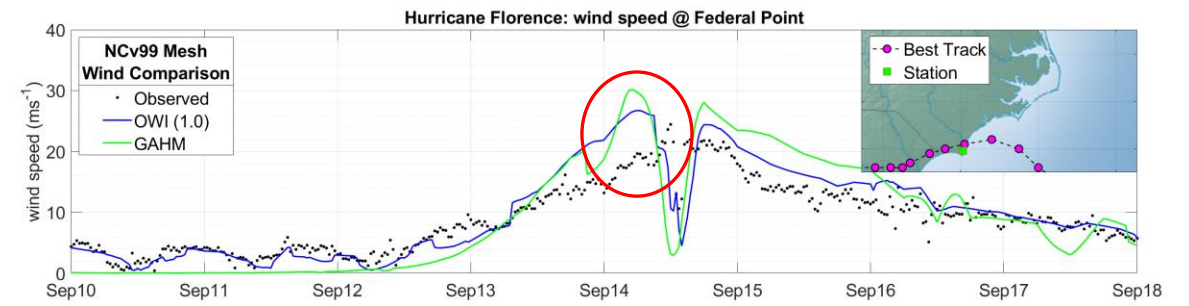


# Accurate Winds in Many Locations...

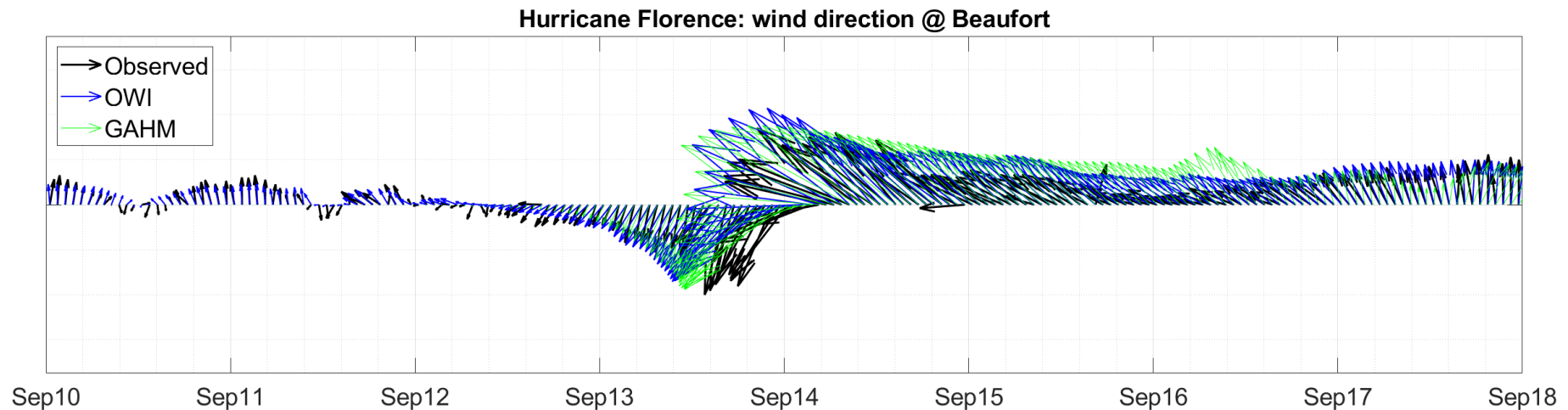
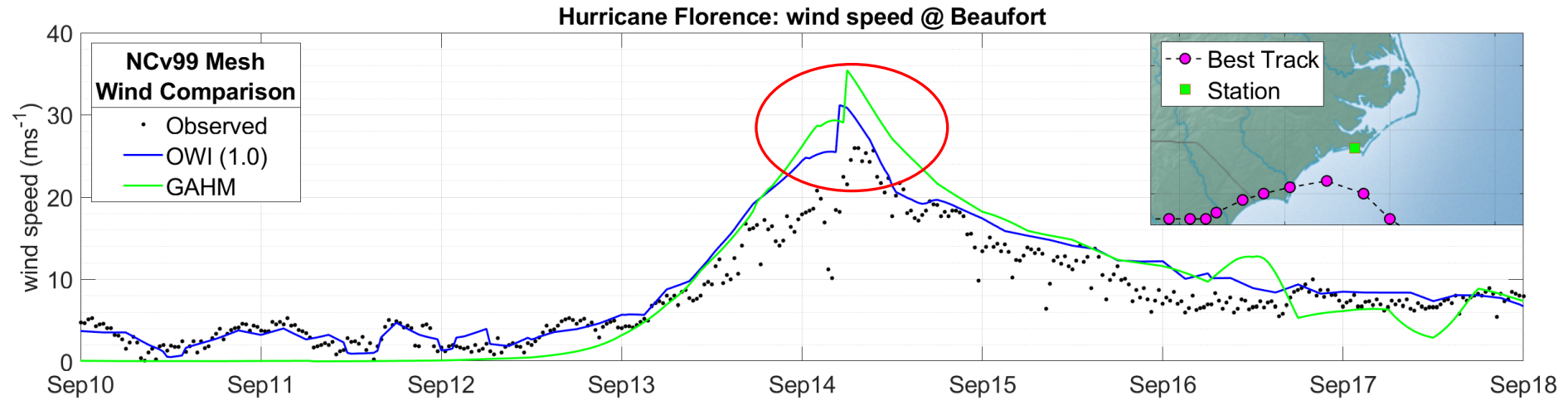




# Overpredicted Winds Push Water Out of Cape Fear River

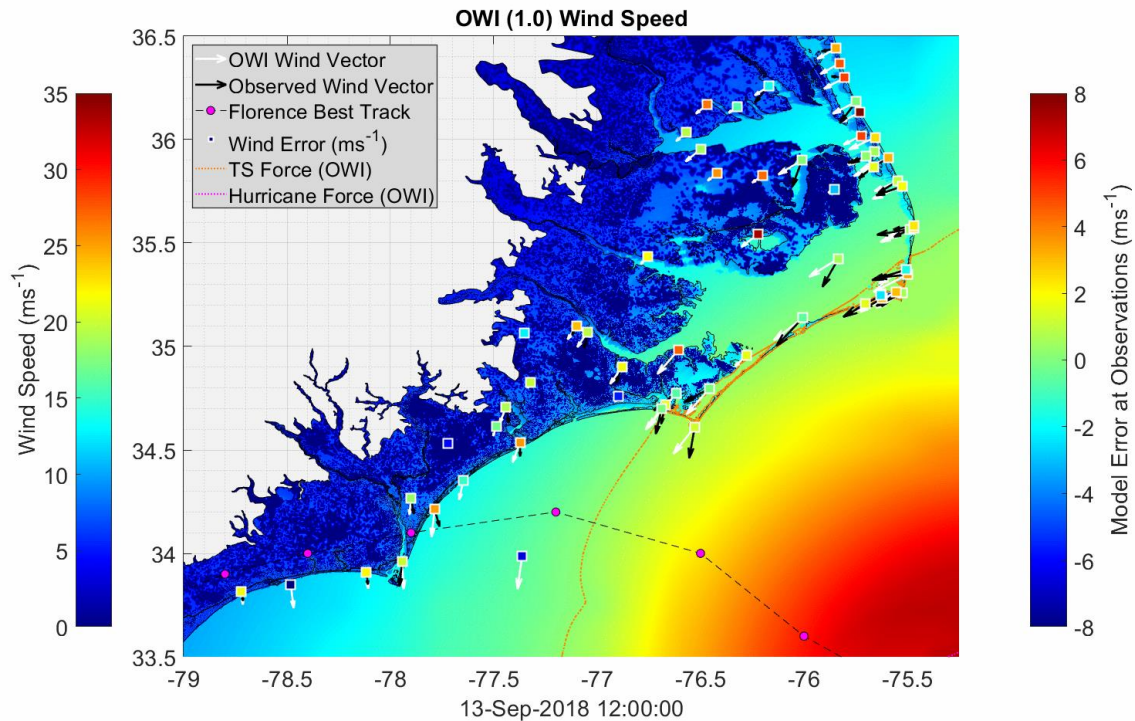


# GAHM Winds ~10-20% Stronger than OWI

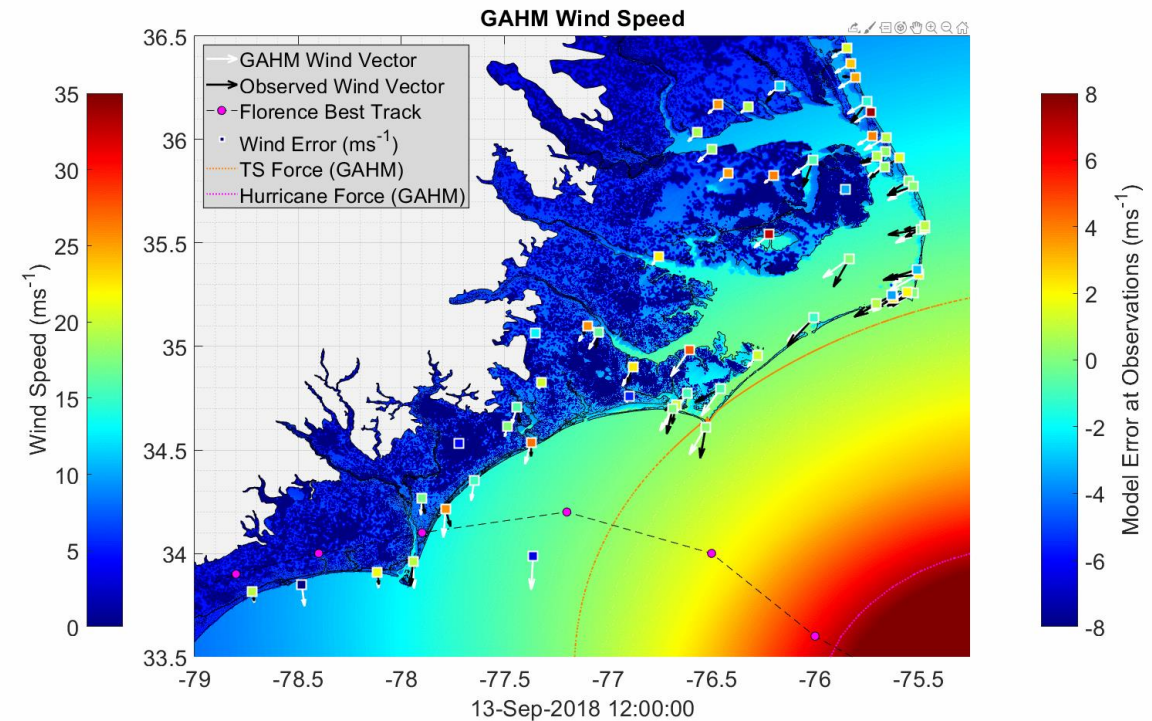




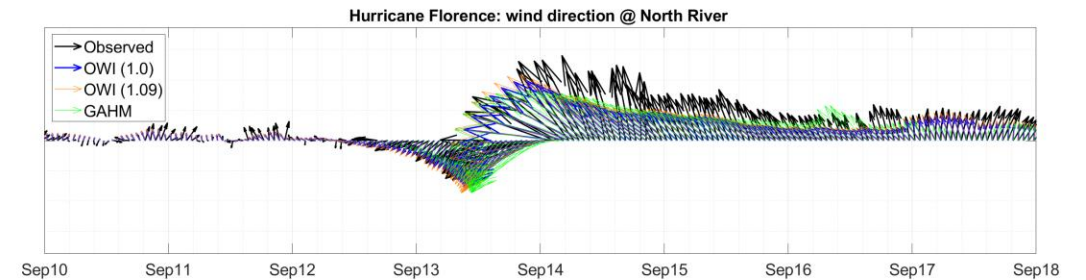
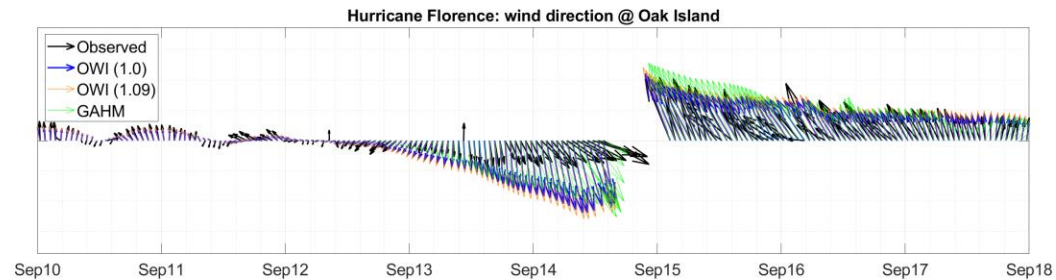
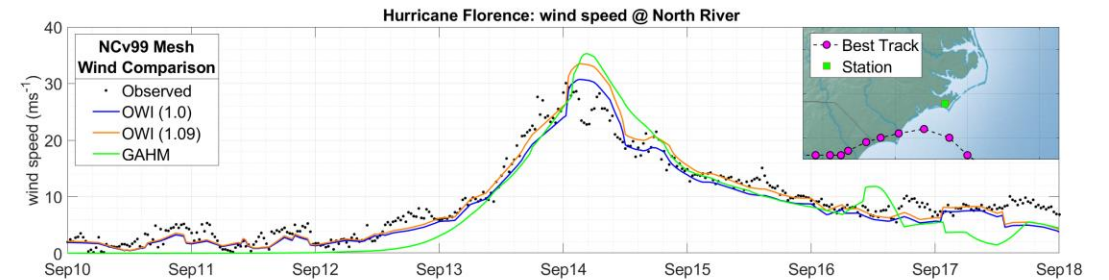
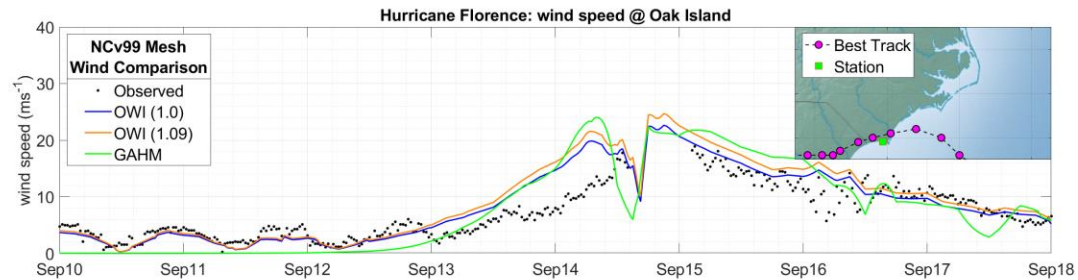
OWI forcing indicates an extended period  
tropical storm level event



GAHM forcing indicates Cat 1 hurricane  
winds onshore for an extended period



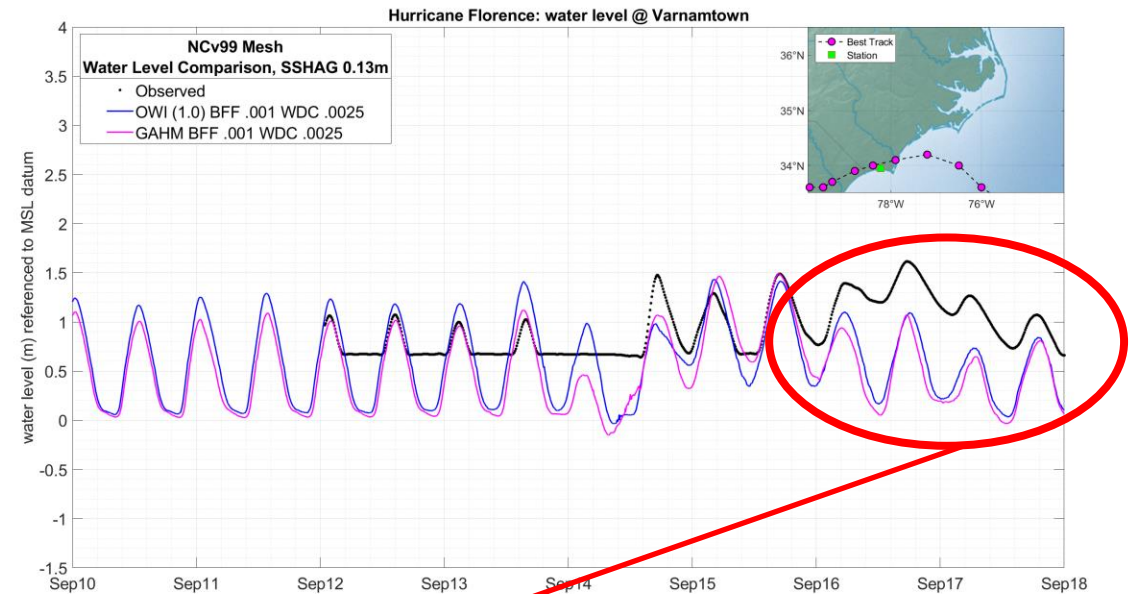
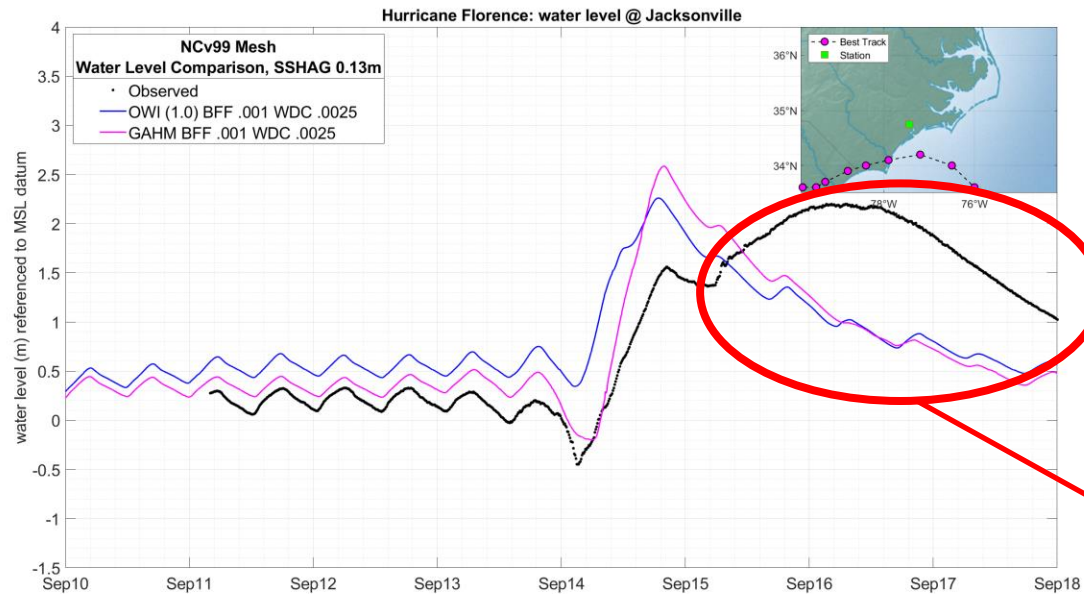
# OWI Wind Scaling Unnecessary



## Scale Down GAHM Winds?

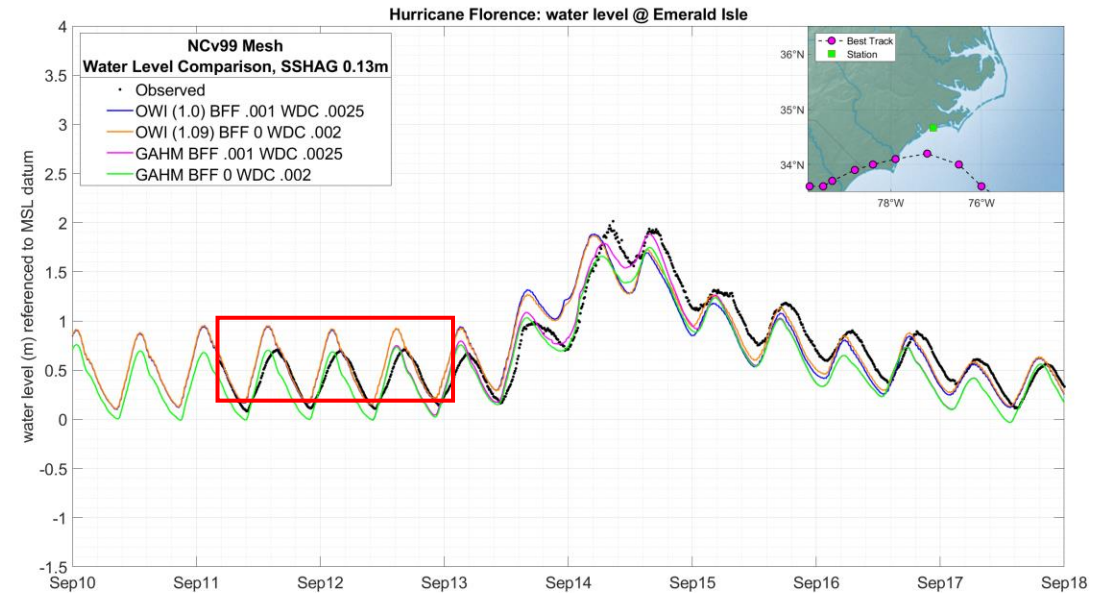
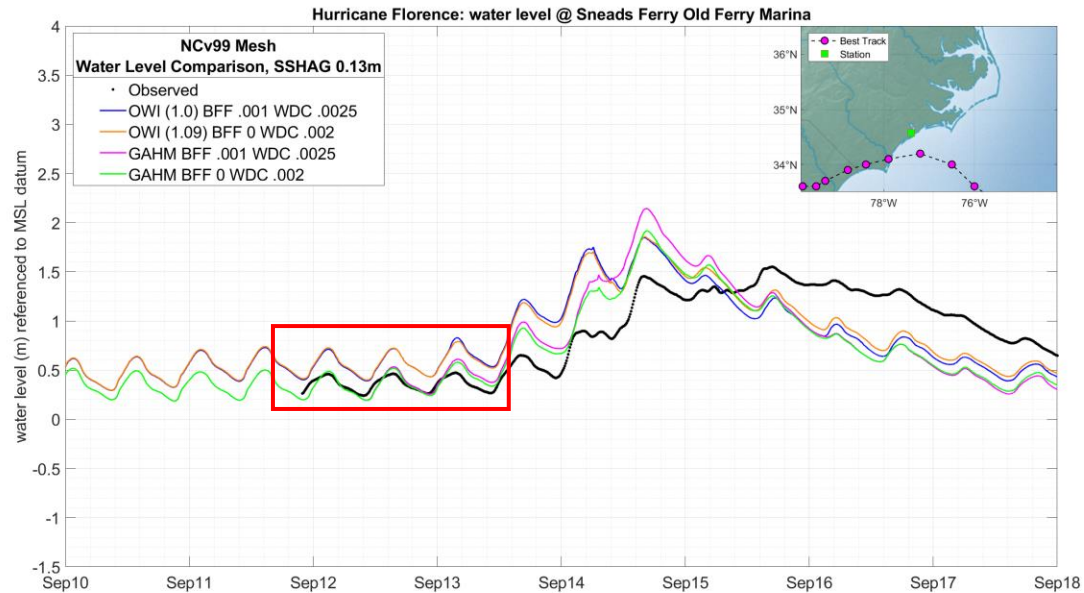


# Compound Flooding in Southeastern NC



Would like to reproduce these observations with the model

# Datum Adjustments?



Water level adjustment from MSL to NAVD88:

NOAA NOS tool, **VDatum**

<https://vdatum.noaa.gov/vdatumweb/>



# Upcoming Work

- Add in variable river flow to model compound flooding
- Work on how to best represent model skill statistically
- How to get GAHM (real-time forcing) performing closer to OWI (hindcast forcing)?
- Explore datum conversions in intracoastal/estuarine areas

# Thank You, Questions?

